
Transmission planning

The planning of Electronic Switched Networks (ESNs) can be partitioned into four major tasks:

- assessing the current equipment to identify locations of nodes, and designating existing equipment to remain in place as main, satellite, and tributary PBX switches
- planning the tie trunk routes
- planning the network routing
- planning off-network call routing

Placement of nodes

The first decision is the choice of locations for node switches. The following transmission factors should be considered:

- The node should be located near a telco toll switching center to minimize the loop plant and short-haul facilities between the node and long-haul facilities.
- The node should be near the middle of its cluster of main PBX switches so that most main-to-node facilities fall in the short-haul category.
- If earth satellite facilities are used extensively, nodes should be located near the earth station facilities.

Once the nodes are designated, the remaining PBX switches are designated as main, satellite, or tributary switches. All switches that have direct trunk groups to a node are main PBX switches. Those switches that access a node via the main PBX are satellite or tributary switches, depending on whether or not they have incoming central office trunks (COTs).

Tie trunk routes

Each pair of nodes in the network represents a potential tie trunk route. Traffic considerations and tariffs determine how many routes are equipped and how many trunks are required for each route. In general, the objectives of lowest cost and best transmission both dictate that the number of tandem trunks required to establish any connection be kept to a minimum. Thus, direct trunk routes should be established wherever practical.

Direct trunk routes represent a radical departure from Tandem Tie Trunk Networks (TTTNs). For TTTNs, routing is usually organized into major trunk route highways with feeder routes. This structure is efficient when alternate routing is not permitted, as with TTTNs, but it is not efficient when alternate routing is supported, as with ESNs. Thus, converting a large TTTN to an ESN can have significant impact on permitted routing.

Network call routing

The direct and alternate routes used for routing calls must be planned so that transmission can be evaluated on each route and appropriate controls established on individual trunks to meet objectives. **Table 2** gives the maximum number of node-to-node routes possible in networks of various sizes. The table establishes the upper limits on the number of routes to ensure that no potential route is overlooked.

Table 2
Route count table (maximum number of node-to-node routes)

Nodes	Direct routes	2 trunks in tandem	3 trunks in tandem	4 trunks in tandem
1	0	0	0	0
2	1	0	0	0
3	3	3	0	0
4	6	12	12	0
5	10	30	60	60
6	15	60	180	360
7	21	105	420	1260
8	28	168	840	3360
9	36	252	1512	7560
10	45	360	2520	15,120
11	55	495	3960	27,720
12	66	660	5940	47,520
Assumptions: Each node has trunks to every other node. All routes that do not include the same node more than once are valid. (In practice, the number of valid routes is considerably less, since many of the routes will not make sense in a real work environment.)				

Transmission controls

Transmission controls are established first for each direct trunk route then for two-trunk tandem routes, then for three-trunk tandem routes, and so on. For each route, an echo suppressor (ES) control or via net loss (VNL) value is specified. (VNL applies to land circuits shorter than 1800 miles [2800 km]; longer land circuits and all satellite circuits require echo suppressor control.)

The required via net loss (VNL) value is determined from the round-trip delay, which depends primarily on the type of facility and distance. [Table 3](#) gives approximate VNL values for varying distances (in airline miles), based on the type of facilities typically provided by a telco. The actual distance could be considerably greater, because the actual signal path is less direct. However, the value includes a margin to accommodate average deviation from direct routing.

Table 3
Loss table for land circuits

Distance in miles (km)	VNL (dB)
0–100 (0–160)	
100–400 (160–640)	1.0
400–700 (640–1120)	1.5
700–1000 (1120–1600)	2.0
1000–1300 (1600–2080)	2.5
1300–1600 (2080–2560)	3.0
1600–1800 (2560–2880)	3.5
Note: Land circuits longer than 1800 miles (2880 km) and all satellite circuits require echo suppressor control.	

Two-trunk tandem routes

Wherever two VNL trunks are in tandem, their VNL losses are summed. If the loss exceeds 4.1 dB, at least one of the trunks should be equipped with echo suppressors (ES) if the route is to be permitted. Normally, the higher loss trunk is selected for echo suppression; the minimization of the number of trunks that must be changed should also be considered. Thus, trunks that appear most frequently in high-loss connections should also be considered prime candidates. Table 4 summarizes this requirement.

Table 4
Transmission control requirements for two-trunk tandem connections

Trunk 1	Trunk 2	Requirement
ES	ES	No action
ES	VNL	No action
VNL	ES	No action
VNL	VNL	If total loss is less than 4.1 dB, no action; otherwise, change trunk 1 to ES or prohibit this connection.

Three-trunk tandem routes

For smaller networks, all three-trunk tandem routes should be sorted and tested for proper controls. For larger networks, the number of three-trunk tandem routes actually permitted is small in comparison to the number of possible routes. Therefore, the more efficient approach is to sort out the permitted routes and to consider only them.

For three-trunk tandem routes, echo suppressor combinations must be considered, as well as total loss. Whenever a VNL tie trunk is connected with echo suppressors between two trunks, the VNL tie trunk must be equipped with echo suppressors (ES) to make sure that intermediate echo suppressors are disabled.

Table 5 summarizes the transmission control requirements for three-trunk tandem connections.

Table 5
Transmission control requirements for three-trunk tandem connections

Trunk 1	Trunk 2	Trunk 3	Total loss if less than 4.1 dB	Total loss if greater than 4.1 dB
ES	ES	ES	No action required	No action required
VNL	ES	ES	No action required	No action required
ES	VNL	ES	Prohibit this connection (preferred) or change trunk 2 to ES	
ES	ES	VNL	No action required	No action required
VNL	ES	VNL	No action required	Change trunk 1 or 3 to ES or connection prohibited
ES	VNL	VNL	No action required	Trunk 2 must be ES or connection prohibited
VNL	VNL	ES	No action required	Trunk 2 must be ES or connection prohibited
VNL	VNL	VNL	No action required	One or more must be ES or connection prohibited
Note: When a trunk is changed to echo suppressor (ES) control, check all combinations in which it appears for routing violations.				

Off-network call routing

The transmission properties of a call depend to a large extent on the type of facilities over which the call is transmitted (see [Table 7](#)). Because of these properties, certain destinations are disallowed for some types of off-network call routing. These are summarized in [Table 6](#).

Table 6
Permitted off-network call routing

Route off-network call				Destinations permitted			
From	By	By	Station	CO trunk	FEX trunk	WATS trunk	Other common carrier
Node			Yes	Yes	Yes	Yes	Yes
Tie trunk	Node		Yes	Yes	Yes	Yes	Yes
Node	Main		Yes	Yes	No	No	No
Node	Main	Tributary or satellite	Yes	No	No	No	No
Main	Tributary or satellite		Yes	Yes	Yes	No	No
Note: Off-network calls to CO or FEX trunks are allowed only within local calling areas.							

Network facilities

Private network facilities

You can order private network facilities from the local telephone company and other common carriers. Although you order facilities on a point-to-point basis, the telco must be informed of the overall planned network and generally assists in the design and selection of facilities. The following facilities can be ordered from the telephone company:

- 2-wire trunks
 - TL 11M/E (E&M Type I signaling)
 - TL 12M/E (E&M Type II signaling)
- 4-wire trunks
 - TL 31M/E (Type I signaling)
 - TL 32M/E (Type II signaling)

Conditioning is the tolerance on frequency response and delay distortion. Several degrees of conditioning beyond basic line quality are available, including: C1, C2, C3, C4, and D1. Generally, the basic line quality is adequate for voice applications. Conditioning is usually required for voiceband data applications.

Table 7
Private network facility requirements

From	To	Facility required	SL-1 cards
Node	Node	TL 31M/E interface (4-wire E&M Type 1)	QPC237
Node	Main	TL 31M/E interface (4-wire E&M Type 1)	QPC237 QPC71
Main	Satellite	TL 11M/E or TL 12M/E (2-wire E&M Type 1)	QPC71

When ordering telco facilities, you must provide the FCC registration number. Different interfaces must be ordered for non-registered equipment. It is acceptable to have registered and non-registered equipment attached to the same facility, as well as to have a tie trunk between telco and customer-provided PBX equipment. Facilities ordered from a telco are furnished with VNL loss (0 dB loss if echo suppression is provided). When customer-owned facilities are used, it is the customer's responsibility to insert the VNL loss into the facility.

Public network facilities

Public network facilities must be ordered from the telephone company. A summary of these facilities is given in **Table 8**. The facilities must be identified as connecting to customer-provided equipment, and the FCC registration number provided. The facilities ordered can include:

- PBX central office trunks
- PBX foreign exchange trunks to specific foreign exchanges
- PBX inward WATS trunks
- PBX outward WATS trunks
- off-premise stations

In addition, you may order direct trunks to SPRINT and other common carrier systems from these service suppliers. These services provide indirect access to the public network.

Table 8
Public network facility requirements

Service required	Facility required
Local calling area	PBX/CO trunk
Calling area local to a distant exchange	PBX/FEX trunk
Wide calling area within the same state	Intrastate WATS outgoing PBX trunk
Calling area, all bordering states	Interstate WATS outgoing PBX trunk, band 1
Calling area within USA, Canada, bordering states, and beyond	Interstate WATS outgoing PBX trunk, band 2 and higher
Calling to major cities in United States	Non-Bell services such as Sprint or MCI